Critical success factors for subway construction projects–main contractors' perspectives

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CRITICAL SUCCESS FACTORS FOR SUBWAY CONSTRUCTION PROJECTS – MAIN CONTRACTORS' PERSPECTIVES

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Abstract

Successful subway construction projects involve many socio-economic, cultural and environmental challenges. These projects enhance public convenience, and are complex and uncertain, involving multiple governmental organisations. The critical success factors (CSFs) of these projects have been identified and prioritised from a main contractors' perspective, to enable project managers to prioritise their efforts and concerns. This study sheds light on critical success factors (CSFs) in subway construction projects and contributes to the project delivery success literature with an overarching focus on the contractors' perspectives. Our investigation revealed that, for subway construction projects in Iran, goal setting through clear and realistic project goals, project management competency, competent project team, good cultural fit, top management support, and adequate funding throughout the project are the top-ranking CSFs. An extensive body of literature is reviewed, and 140 potential success factors are identified. Then a focus group has been conducted in which the potential CSFs reduced to 39 success factors. The priorities and ranking of the success factors were evaluated according to the views of 63 project managers of subway projects. The Correlation coefficients analysis was used to analyse the

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results, and it revealed that 23 success factors such as goal setting, top management support and PM competency were perceived to be critical by the respondents. No other research has, until now, found the critical factors leading to success in subway construction industry in Iran. The results have been verified against other research done in other countries.

1. Introduction

The Iranian economy is growing at a relatively rapid pace. From 2013, the growth rate has significantly increased from -1.9% to 4.6% in 2014 (https://data.worldbank.org). Massive investments for the construction and development of subway systems have been injected through the years to reduce transportation problems, particularly in Tehran (the 24th largest city in the world, according to http://www.citymayors.com). These efforts have not only to cope with the demands of a rapidly developing economy but also to ensure that the country's competitiveness in global markets is not compromised by the lack of a reliable, quality transportation system. Although Tehran as a metropolis enjoys a massive network of highways (280 km) and an extensive bus rapid transit (BRT) line (100 km), traffic congestion is one of the most irritating problems in Tehran which has become intolerable and at times agonizing for locals during rush hours, due to the growing population and increasing private vehicle ownership (Forouhar, 2016).

Subways are constructed in major cities like Tehran to overcome the transportation problems associated with urbanisation. Statistics from TUSROC's website indicate that more than 129 million trips using subway happened during spring of 2011 in Tehran, and more than two and a half million people are now using the subway daily (Bagheri 2017). "Almost 60% of Tehranies use the metro on a regular basis, and over half of the trips are either for shopping (28%), work (19%), or going to Tehran's CBD (15%). Worldwide, Tehran's subway ranks 15th in terms of the number of passengers per day and 20th regarding network length which was 128 km in 2012" (Bagheri 2017, p.7). Looking at these figures, the

economic benefits of subway construction are clear. Thus, subway construction projects are essential in Tehran given the city's traffic congestion. The success of such projects is vital for sustainable economic growth and social well-being (Ghanbaripour et al., 2015).

Through the years, the Iranian government has made considerable investments in transportation systems and expended substantial effort in expanding its network. According to Jin et al. (2012), infrastructure is vital for the development of the country. These projects play a crucial role in the construction industry of the country. It acts as a key to attracting foreign capital to developing countries (Jin et al., 2012). In this regard, public transportation in Tehran (population over 9 million) should mitigate the problems arising from the lack of an adequate transportation system and consequently reduce air and sound pollution. As a result, subway projects have received a significant share of public sector development expenditure. Thus, improving the project and construction management processes of these projects by identifying the critical success factors should be beneficial.

However, subway construction is not without problems. The main reasons for unfavourable outcomes fall into several categories. Construction projects rely on the integrated efforts of several hierarchically linked parties (including architects, engineers, surveyors, general contractors, subcontractors and suppliers) using their specialist skills, knowledge and technology. Normally, these parties are independent organisations with separate objectives and goals, management styles and operating procedures (Chen and Chen 2007). “A metro system is usually designed to be utilised for the crowded area of cities. The process of constructing such systems, obviously, interrupts daily civilian life. This issue illustrates the importance of adequate management and planning to deliver metro projects on time and budget with high quality and efficiency (Khosravi and Kähkönen, 2015)”. These projects are complex and dynamic, and their success or failure cannot be measured with a simple test like the

compressive strength of a concrete mix. Constructing public infrastructure projects successfully, requires economy, efficiency, quality, fairness and transparency (Tabish and Jha, 2011).

This study of identifying CSFs is timely, as it is one of the essential ways to understand the main factors leading the projects of a particular industry to success at a specific time. The importance of this endeavour is of high significance since a shared understanding of these CSFs facilitates effective monitoring and controlling of these projects' performance for project owners and managers, who need specific and measurable frameworks for tracking key project outcomes. It is also well known that CSFs are necessary for the appropriate allocation of various project resources (Ahadzie, 2007; Cox et al., 2003; Chua, 1999).

Achieving success in public projects is difficult because it requires economy, efficiency, quality, fairness and transparency (Tabish and Jha, 2011). Many factors contribute to project success. In this study, CSFs are ranked based on contractors' perspectives since construction projects, and their success is highly dependent on contractors (Alzahrani and Emsley, 2013; Banki et al., 2009; Ng et al., 2009). According to Alzahrani and Emsley (2013), when the contractors begin their main duties, it impacts upon project success when the project reaches the construction or execution stage. Therefore, this study aims to discover the factors contributing to subway construction projects' success from a contractors' perspective.

Toor and Ogunlana (2006) observe that most studies on CSFs for construction projects are context-specific. Therefore, the specific implications of studies on success factors are limited to the countries and cultures in which these studies have been conducted. Toor and Ogunlana (2008) suggest that more studies should be performed in other states to account for the nature and structure of the local construction industry, the scale of construction projects, procurement strategies, the maturity of the organisations concerned, and local cultural values and norms. Also, ever-changing socio-economic and

cultural changes have become increasingly sophisticated and perplexing. This, together with the globalisation of the construction industry, poses numerous challenges to those concerned at all levels (Lewis, 2006; Ofori, 2007; Raftery et al., 1998).

This paper is divided into five further sections. A comprehensive literature review of project delivery success and CSFs is provided in the next section, and a set of 140 potential factors are extracted for subway construction projects from past research. Then the methodological approach of the study is presented, and the process of identifying possible factors is explained that how the authors condensed the factors mentioned above into 39 success factors, and it is followed by an analysis and discussion of the results. The final section reflects on the conclusion and verification of the results.

2. Context to the study

2.1.Project Success

Project success has been discussed at length in project management literature (Carvalho and Rabechini Junior, 2015), revealing the social and political contextualization of performance in project management (Sage et al., 2014). The traditional view of project success is associated with fulfilling time, cost and quality objectives (the iron triangle), and this view arises from Martin Barnes's 'iron-triangle' consisting of the core project constraints that he introduced in 1969 (Langston, 2013; Carvalho et al., 2015).

Project success may be assessed regarding efficiency in the short term and effectiveness in achieving the expected results in the medium and the long-term (Jugdev et al., 2001; Müller and Jugdev, 2012). There seems to be no simple definition of this construct. Project success may be measured differently for different types of projects, from different perspectives, at various stages, and in absolute or relative terms (Samset, 1998). It is a multidimensional construct (Carvalho and Rabechini Junior, 2015; Samset, 1998; Shenhar and Dvir, 2007) and different stakeholder groups have their perceptions of

project success (Chou and Yang, 2012; Davis, 2014, Toor and Ogunlana, 2010; de Vries, 2009). However, despite different success criteria for different projects, Langston (2013) introduced a model using six generic key performance indicators (KPIs) that were ratios of the core constraints of the project namely scope, cost, time and risk to enable comparison of projects in terms of delivery success regardless of type, industry, size or time.

Several valuable studies have been conducted on project success, mostly focusing on two dimensions, namely success criteria (the measures by which success or failure of a project or business will be judged) and success factors (the inputs to management systems that lead directly or indirectly to the success of the project or business) (Cooke-Davies, 2002). Criteria for success and critical success factors are two relevant keywords used in project and project management contexts. While 'success criteria' are the standards on which a judgment or decision about project success are based (Gibson and Hamilton, 1994), 'critical success factors' (CSFs) are the key areas of activity in which favorable results are necessary for a particular manager to reach his or her goals (Rockart, 1982). Understanding the distinction between these terms is essential for the formation of CSFs for construction projects. This provides researchers with a clear direction of the subject matter to avoid possible confusion (Yong and Mustaffa, 2013). Authors argue that being aware of the CSFs relevant to a specific project, particularly in subway construction projects in Tehran, will help project managers to allocate their resources and practices advantageously and lead to successful outcomes.

2.2.Critical Success Factors in the construction industry

From a project management perspective, CSFs are the characteristics, conditions, or variables that have a significant impact on the success of projects when adequately sustained, maintained, or managed (Milosevic and Patanakul, 2005). Different studies have identified different CSFs. There is

a lack of consensus among researchers about the criteria for judging project success and the factors that influence that success (Fortune and White, 2006).

Success has always been the ultimate goal of every activity, and a construction project is no exception. The construction sector is distinct from other areas of the economy and is characterised by a high rate of failures (Elattar, 2009).

It is believed that the definition of success factors is a prerequisite for an organisation's success and a way for measuring its maturity level (Khandelwal and Ferguson, 1999). The most common CSFs have been presented by Cooke-Davies (2002), Judgev and Muller (2005), and Ika et al. (2012).

Attempts have been made to identify and validate the relevance of CSFs for diverse types of construction projects such as mass housing projects (Ahadzie et al., 2008), design and build projects (Chan et al., 2001; Lam et al., 2008), BOT projects (Tiong, 1996), and public-private partnerships in infrastructure development (Zhang, 2005). Most of these studies have adopted research approaches that first extracted sets of project success factors based on reviews of relevant literature and project characteristics, and then validated them quantitatively or qualitatively through questionnaire surveys (Yu and Kwon, 2011). Research conducted in Australia presents a more recent perspective on construction project management success (Doloi and Lim, 2007). Several CSFs were identified including detailed planning of project budgets and cost control, project time planning and schedule control, human resources management (including support and communication), project quality control, abilities of team members to perform the required tasks, the information and specification available, project complexity, personnel with construction industry experience, project contingencies, well-defined and detailed breakdowns of project structures and project milestones (Doloi and Lim, 2007; Ribeiro, 2013). The Construction Industry Institute of the University of Texas (CII, 2011) proposed a set of 14 areas of expertise derived from extensive research and benchmarking processes

158 to be mastered to guarantee project management success in the construction sector. These areas of
159 knowledge also address technical and management factors including project planning, design
160 optimization, materials procurement and management, construction start-up and operations, human
161 resources management, project organization management, business and project processes, project
162 control, risk management, safety and health, environmental protection, information and technology
163 systems management, globalization issues and security (Ribeiro, 2013).
164 However, there are few studies on CSFs for subway construction projects. As mentioned before, in
165 this study 140 CSFs are extracted from relevant academic papers. Then a focus group approach
166 adopted to identify the potential pertinent CSFs to subway construction projects. After this
167 consolidation process, a more manageable number of 39 success factors remained. Focus group
168 discussions allow participants' perceptions, feelings, and experiences to be interwoven and stimulated
169 to widen the range of opinions on specific topics and avoid individual bias (Morgan et al. 1998).
170 Previous research has categorised CSFs in different ways. Jin et al. (2012) suggested that the potential
171 CSFs for infrastructure projects may be grouped under the following main categories: (1) Project
172 Management-related (PM) factors; (2) Client-related (CL) factors; (3) Design team-related (DS)
173 factors; (4) Contractor-related (CN) factors; and (5) Business and Work Environment-related (EN)
174 factors. Inayat et al. (2014) used four categories of project characteristics, contractual arrangements,
175 project participants and interactive process. In a study of critical success factors for construction
176 projects in Lithuania, Gudiene et al. (2014) classified the CSFs into seven groups of external factors,
177 institutional factors, project-related factors, project management/team-related factors, project
178 manager-related factors, contractor-related factors and client-related factors. All the CSFs presented in
179 these texts have been distilled into the four categories shown at the bottom of Table 1 (i.e. Client-
180 related, Project management and planning-related, Project team-related and External Factors).

"Insert Table 1 here"

Table 2. shows 140 all potential success factors extracted from relevant references: *Walker (1995), Toor and Ogunlana (2008), Songer and Molenaar (1997), Chua et al. (1999) Dissanayaka and Kumaraswamy (1999), Kumaraswamy and Chan (1999), Mayer et al. (1995), Munns (1995), Hartman (2002), Cheung et al. (2003), Walker and Hampson (2003), Kadefors (2004), Nguyen et al. (2004), Pinto et al. (2009), Pinto and Slevin (1988), Chua et al. (1999), Cooke-Davies (2002), Nicolini (2002), Andersen et al. (2006), Fortune and White (2006), Sambasivan and Soon (2007), Belassi and Tukel (1996), Sanvido et al. (1992), Meng (2012), Songer and Molenaar (1997), Lim and Mohamed (1999), Kong and Jason (2006), Takim et al. (2004), Chan and Kumaraswamy (1996), Low and Chuan (2006), Dainty et al. (2005), Munns and Bjeirmi (1996), Belout and Gauvreau (2004), Akintoye (2000), Alaghbari et al. (2007), Construction Industry Development Board Malaysia (2006), Construction Industry Development Board Malaysia (2006), Sambasivan and Soon (2007), Narayanan and Lai (2005), Eriksson (2006), Abdul Rahman et al. (2010), Jha and Iyer (2007), Lam et al (2008), Yu and Kwon (2011), Yong and Mustaffa (2013), Gudienė et al (2014), Inayat et al (2012)*

"Insert Table 2 here"

3. Research Method

This research identified and analysed the CSFs based on main contractors' perspectives considering the following facts. Firstly, main contractors make major contributions to the development of subway projects in Iran. Their actions and decisions affect all aspects of these projects. For example, many of them are selected based on their ability to provide sufficient financial resources since they may be paid months or years after a project's termination. Hence, contractors play an important role not only in the construction phase but also in the program, design, and post-construction phases of these projects. Secondly, there is insufficient research that deals with main contractors' views of CSFs for subway projects in Iran. Thirdly, these contractors have longstanding and extensive experience of construction projects, and their perspectives on success factors are robust, informative and valuable to stakeholders such as the government, consultants and academic researchers. These reasons motivated the authors to conduct this study from the perspectives of main contractors.

The focus of this research is to identify and evaluate the success factors of subway construction projects. An extended literature review was conducted and140 potential success factors for construction projects were extracted. A focus group reduced these success factors to 39. Then, a questionnaire-based survey was undertaken to achieve the views of experienced subway construction professionals on these success factors and to rank them based on the mean score of each factor. The whole process was conducted in four steps as follows:

Step 1: Focus group

Focus group discussions allow participants' perceptions, feelings, and experiences to be interwoven and stimulated to widen the range of opinions on specific topics and avoid individual bias (Morgan et al. 1998). Hence, focus groups emphasise the results of interactive discussions among representative participants rather than those of individuals within a group (Leung et al., 2014).

All success factors extracted from literature (shown in Table 2) were considered to develop a list of factors for empirical testing. These factors were reduced during a two-session focus group (each session lasting two hours), attended by some professionals experienced in subway construction projects. A total of seven project managers participated in this exercise. These participants were selected based on the following criteria:

- All focus group participants had at least ten years of experience in the construction of subway projects (predominantly in Tehran).
- Furthermore, all participants had been involved in at least five projects, meaning that they had accumulated diverse experiences which enabled them to provide informed opinions about the factors that contribute to the success of subway projects.
- All participants held senior positions in their companies and were project managers.

The candidate project managers were identified from a list of companies involved in this industry. They took part in a focus group meeting to reduce the number of potential factors. Invitations were sent via email to project managers working on these projects. Finally, the meeting was held with seven PMs. In this meeting, each factor was voted on and the plurality method according to PMBOK 2012 (Fifth Edition) was used to eliminate less critical factors. "Plurality is a decision that is reached whereby the largest block in a group decides, even if a majority is not achieved. This method is generally used when the number of options nominated is more than two" (PMI, 2013, p. 115). The plurality or simply 'first past the post' is the simplest form of voting. Each voter has one vote, which can be cast for any success factor. The factor with the highest number of votes remains on the list. The benefits of the plurality method are its simplicity and ease of use (Van Erp et al., 2002).

The fact that the factors could be summarised in such a drastic way indicates that there seems to be a standard base of CSFs over different domains (Gepp et al., 2014). Finally, 39 success factors were determined as shown in Table 3, and these constituted the basis for the empirical survey questionnaire. "Insert Table 3 here."

Step 2: Questionnaire development

A questionnaire was developed based on 39 success factors resulting from the focus group. These success factors were presented to respondents using a paper-based survey. Respondents were invited to judge the importance of the 39 CFSs. All respondents were project managers as senior staffs of their organisations and all of them were engaged in subway construction works for at least one year. Since there are 63 running projects with project managers working for subway projects' contractors, all of them were asked to participate in this research. These attendants were asked to rank the CSFs for the project they were currently involved with (their 'case project'). The rating for each success factor was sought on a five-point Likert scale in which '1' represented 'strong disagreement' and '5' represented

‘strong agreement’. The five-point scale includes immediate values among adjacent values and helps the respondents express their judgments subjectively and in an effective way (Tabish and Jha, 2011). Likert scales imply that the actual number of choices may be left to the tastes of individual researchers. In practice, researchers often do assign the number of choices arbitrarily according to personal taste or past convention (Munshi, 2014). Nevertheless, it is argued that the inclusion of midpoints on a scale is necessary. This is because it cannot be definite whether the meaning of “agree” or “disagree” response, for instance, really implies the respondents’ agreement or disagreement towards the items. Some respondents may select these two options because there is no an option referring to “neutral”, “undecided” or “don’t know”. In this sense, authors may need to take a risk that they may make an inaccurate conclusion due to the scale without such midpoints (Tsung, 2012).

The Cronbach’s α coefficient was used to determine the responses’ reliability. An “α” exceeding 0.9 indicates high reliability, α between 0.9 and 0.7 indicates acceptable reliability, and α below 0.35 indicates low reliability (Fowler, 1993; Gay, 1996). For this questionnaire, Cronbach’s α of 0.928 was achieved. This result confirmed the appropriateness of further analysis of the data.

In this study, validity was used to ensure accurate measurement of the factors. As the selection of the initial items (CSFs) was based on a review of the theoretical and empirical literature, it is vital to assess internal validity. Authors brought the questionnaire to seven participants, and via face-to-face meetings they were asked to complete a pilot survey and to present a critique of the questions. Results demonstrated the validity of the questionnaire.

Step 3: Selection of respondents

A list of ongoing subway construction projects was developed by the information obtained from TUSROC (http://metro.tehran.ir/). To examine the characteristics of a target population, a representative sample should be selected, representing the features and attributes of the community in question. The

target population for this study was all 63 PMs of subway construction projects in the metropolis of Tehran who were working for the contractors of subway projects at the time.

The questionnaires were distributed personally by the first-named author. From April to November 2015, the author travelled around Tehran to places where, according to TUSROC, a subway station or tunnel was being constructed and conducted face-to-face meetings to explain the purpose of the study and to hand in the questionnaire personally to the project manager and then collected each of them after one week. Sixty three Tehran subway construction PMs were located, and questionnaires were distributed among all of them. According to Baruch and Holtom (2008), when conducting such research, scholars depend on the willingness of people to respond to the questionnaire. However, Rogelberg and Stanton (2007) state that a 100 percent response rate (RR) is unlikely to be achieved unless the questionnaire is coercively administered to the target population (Baruch and Holtom, 2008). In this study, although the authors handed in the questionnaires to the project managers personally, they used to follow it up with PM's assistants several times to ensure that the project manager would fill out the questionnaire.

Subway construction projects in Tehran are awarded to contractors based on a structured process. Although some minor changes happen because of the location, financial issues and organisational culture of the contractor firm, these projects are planned to be typical in scale, size, cost and duration. Needless to say, all these mentioned parameters for tunnel projects differ from stations.

Step 4: Analysis method

The analysis included identifying the significant success factors based on their mean ratings by the following formula (Lew et al., 2003):

$$MS = \frac{\sum(f \times s)}{N} \ (1 \leq MS \leq 5)$$

Where “f” is the frequency of responses to each rating, “s” is the score given to each factor by the respondents and ranges from 1 to 5 and “N” is the total number of responses concerning that factor. It is important to note that the ranking exercise is based on perceived importance (Yong and Mustaffa, 2012).

4. Analysis and Discussion

4.1. Background

A brief characterisation of the responding PMs shows that the majority were male (90.5%), over 36 years old (71.4%), although almost 30 percent are under 35 years old. As can be seen from Table 4, more than 65 percent have been involved in the project management of subway construction projects as a PM for more than six years and 23.8 percent for more than a decade. Moreover, all of the participants have a university degree, 42.8 percent of which have a post-graduate degree. The majority (74.6%) have more than five years of experience in civil engineering, and 57.1 percent have more than ten years of experience.

“Insert Table 4 here”

4.2. Ranking of CSFs

Table 5 presents the result of the analysis of the success factors. A total of 39 success factors were ranked according to their mean values.

Analysis results of this study are in line with numerous other studies conducted in the other parts of the world (Yong and Mustaffa, 2013; Toor and Ogunlana, 2009; Inayat et al. 2014). Rating of success factors in Table 5 reveals high-scoring success factors are mostly related to three main factors which are: Project Management (e.g. Goal Setting, PM Competency, Performance Management); Project Team (e.g. effective allocation of human resources, competent project team, good cultural fit); and involvement of client (e.g. top management support, adequate funding).

“Insert Table 5 here.”

318 Figure 1 depicts the main CSFs (with a mean more than 4.05), categorised into three major parts of
319 projects.
320 "Insert Figure 1 here."
321 All CSFs are classified into three categories. This classification is suggested by the authors and then
322 confirmed by the all seven participants of the focus group. All seven experts agreed with this
323 categorisation.

324 ***4.3. Project Management and Planning Factors***

325 Table 6 indicates the results of the analysis of the questionnaire responses with regards to project
326 management and planning-related factors. Nine factors were identified in this category. Goal setting and
327 PM competency are the top two factors, having a mean score (MS) of 4.714 and 4.460, respectively.
328 While the adoption of innovative management approaches scored an MS of 4.159, clear and detailed
329 written contracts have a lower MS of 4.095, suggesting that it has a less significant influence on the
330 success.
331 The first ranked CSF was 'goal setting', indicating that apparently identified goals at various levels were
332 highly crucial to subway projects success. Several investigations have found this CSF to be essential for
333 the success of construction projects around the world (Nicolini, 2002, Nguyen et al., 2004, Fortune and
334 White, 2006, Toor and Ogunlana, 2009, Yong and Mustaffa, 2013, Zhao et al., 2013).
335 Project manager's competency ranked second. While many researchers emphasised the skills of
336 consultants and contractors, some focused on the competencies of developers and project managers. In
337 this regard, developers and project managers must be competent to respond to different situations to
338 avoid ambiguities throughout the project period (Yong and Mustaffa, 2013).
339 The success of a project can be achieved by the diligence and competence of a project manager.
340 Competence is a critical factor affecting a project's planning and implementation (Gudiene et al. 2013).

341 According to Bourne and Walker (2004) in most organisations, project managers are accountable for the
342 successful delivery of entire projects. Increasingly, this success depends on project managers'
343 processing and utilising skills and competencies that may initially appear contradictory. A successful
344 project manager must demonstrate flexibility and competency in many areas, including hard and soft
345 skills, as well as introverted and reflective, extroverted and social behaviours. Inayat et al. (2014) found
346 that PM competencies were ranked among the top 10 CSFs by construction managers and design firms,
347 and in Lithuania, Gudiene et al. (2014) ranked several CSFs in the construction industry and their study
348 revealed that the project managers' competence ranked in the top ten of 71 success factors. Also, Jin et
349 al. (2012) studied the CSFs of developing infrastructure projects in Malaysia, and PM competency
350 ranked ten among 33 factors.
351 The third-ranked success factor is "performance management at each phase". This involves monitoring
352 progress and goal achievements. To control them appropriately, project performance should be managed
353 in an appropriate manner (Yu and Kwon, 2011). Effective performance management in each phase of a
354 project should reduce rework which helps project teams to finish the project on time and within the
355 planned budget. Cooke-Davies (2002) found that maintaining the integrity of the performance
356 measurement baseline is a real success factor in European construction industry.
357 As can be seen in Table 6, effective allocation of human resources is a significant critical success factor
358 in subway construction projects. Yong and Mustaffa (2012) showed that this factor ranked first in the
359 category of project-related factors in the Malaysian construction industry. Having adequate resources
360 but weak planning will result in loss of control and poor outcomes. This should be done in the very
361 initial stage of a project (Toor and Ogunlana, 2009).
362 "Insert Table 6 here."

363 ***4.4. Project Team Factors***

Table 7 presents the results of the analysis of project team-related factors that contribute to the success of subway construction projects. The findings suggest that the first component that seemed to capture the PMs' general attention was "multidisciplinary/ competent team", having an MS of 4.381. The need for competent project teams has been mentioned in several studies (Belout and Gauvreau, 2004; Rogers, 1990; Sommerville and Dalziel, 1998). The active contribution and assistance rendered by key project players depend significantly on the capability of the critical personnel and the overall competency of the team assigned to the project (Hwang et al., 2013). A team with expert, knowledgeable, experienced, and skilled team members are essential for the successful accomplishment of project goals. Kulatunga et al. (2009) emphasised that selecting a competent team is necessary, ranking this as the third most important factor in construction R&D projects.

Good cultural fit ranked third with a mean of 4.302 among project team-related success factors. Partnering parties have their preference for their organisations. Because of cultural diversity, individual parties tend to be dominated by their own goals and objectives, which can be conflicting and consequently may cause adversarial relationships (Love et al., 1998). Effective communication can facilitate the exchange of ideas and visions, reducing misunderstandings and stimulating mutual trust. Such communication involves the formation of active communication channels, which can be used to motivate partners to jointly participate in planning and goal setting and thus cooperate to create compatible expectations (Chen and Chen, 2007).

Favorable working conditions are an essential success factor in subway projects with a mean of 4.238 (Table 7). The physical environment is part of the human environment that includes purely physical factors (natural disasters, weather, pollution, noise). It affects project participants, their working conditions and the successful implementation of projects (Gudine et al., 2013). According to Jha and

386 Iyer (2007), factors such as “favourable working condition” were found to be essential factors enhancing
387 the cost performance of projects, which is a vital factor leading the project to success.
388 “Insert Table 7 here.”

389 ***4.5. Client-Related Factors***

390 Table 8 shows the ranking of the client-related factors. Among the six CSFs affecting subway
391 construction projects, the highest mean (4.492) was given to top management support from client
392 organisations. The least important was the client’s responsiveness to the needs of the other stakeholders
393 with the mean of 4.127. When all 39 factors are considered, there are six client-related factors among the
394 top critical success factors (MS >4.055). Adequate funding throughout the project is ranked sixth, and
395 project consultant’s competence (consultants who were chosen by the client in the initiating phase of
396 projects) is listed the tenth.
397 “Top management support” which ranks first in the category of client-related factors, has been
398 considered as a significant success factor in an overwhelming number of investigations. Jin et al. (2012)
399 found that adequate support from top management is a “very significant” CSF in developing
400 infrastructure projects in Malaysia (ranked 11 among 33 factors). According to Belout and Gauvreau
401 (2004), it is understood that top management support is a necessary condition for conducting subsequent
402 operations. Moreover, the commitment and dedication of all related parties in the project, especially the
403 support from top management, as well as clear communication of mutual needs, issues, and solutions
404 among the stakeholders will significantly improve overall project performance (Yong and Mustaffa,
405 2012). Jha and Iyer (2007) stated that essential factors like top management support tend to keep the cost
406 performance of projects at the same level and contribute significantly in enhancing project quality
407 performance from its existing level.

In most construction projects around the world, adequate funding throughout the project is considered a critical success factor. In this study, it ranks second among other client-related factors with a mean of 4.444. This shows that how important it is for subway projects to obtain financial support. The factor, adequacy of funding, refers to the timely provision of monetary resources by the owner to the contractor as an acceptance of the work done by the latter (Inayat et al., 2012). Clients should adequately address the financial needs of other stakeholders (Toor and Ogulana, 2009). Inayat et al. (2014) found that adequacy of funding and site inspections qualified among the top 10 CSFs for contractor organisations and construction managers but not for design firms. It is understandable that overall project performance for contractors and managers is dependent on the adequacy of funding and site inspections. Delayed site inspections cause a backlog in managers' verifications of contractor payment requests, which result in reduced funding for contractors, which in turn hampers contractors' abilities to finance upcoming construction activities. Hwang et al. (2013) stated that adequate funding for project completion is crucial as illiquidity may result in projects being heavily burdened by debts. With inadequate cash flow to meet operating needs, contractors in Singapore have a right to stop work under the Security of Payment (SOP) Act upon nonpayment and can even claim losses against the owner for work postponement. In regards to the construction industry in Malaysia, the financial capability of clients ranked first among client-related CSFs (Yong and Mustaffa, 2012).

Since there are numerous severe conflicts between consultants and contractors in subway construction projects, the competency of project consultants is a significant critical success factor. Consultants are expected to furnish adequate design details, specifications and advice to their clients and contractors (Yong and Mustaffa, 2012). According to Inayat et al. (2015), for overall project performance, designers ranked competency of contractor teams, the capability of consultant key personnel, and competency of consultant teams among the top 10 CSFs in an Agency Construction Management Environment.

431 “Insert Table 8 here.”

432 In this study, the relationship between the variables was determined by the 39 identified CSFs measured
433 by the correlation coefficients of each pair of variables. Tables 9 and 10 illustrate the matrix of the
434 correlation coefficients among the CSFs for subway construction projects. The correlation coefficients
435 demonstrate that the CSFs share common factors. The Bartlett test of sphericity is 3220, and the
436 associated significance level is 0.000, indicating that the population correlation matrix is not an identity
437 matrix. Moreover, the value of the Kaiser–Meyer–Olkin (KMO) measure of sampling accuracy is 0.663,
438 which exceeds 0.5 and thus is considered acceptable.

439 For this research, values greater than 0.50 were accepted as indicators of significant correlation. “Goal
440 setting” and “performance management at each phase” have a significant correlation with “top
441 management support from client organisation” with values of 0.762 and 0.746, respectively.
442 “Contractor’s competence and experience” and “PM competency”, “adequate funding throughout the
443 project” and “favourable working condition”, “financial security” and “top management support from
444 client organization”, “favourable working conditions” and “PM competency”, “Performance
445 management at each phase” and “financial security” are all significantly correlated.

446 “Insert Table 9 here”

447 “Insert Table 10 here”

448 ***4.6. Comparing the results to that of other contexts***

449 From the previous sub-section, goal setting ranked first among all other CSFs for subway construction
450 projects. For Verburg et al. (2012), goal setting showed significant importance as a factor for successful
451 project execution in a dispersed setting. For Sudhakar (2012), both goal setting and top management
452 support were identified as essential success factors in software projects. Looking at electrics and
453 electronics industry, Wittstruck and Teuteberg (2012) found that the support of Sustainable Supply

Chain Management (SSCM) activities at top management level should be considered as a success factor since it is of central importance for mutual learning processes. In another study, Tarhini et al. (2015) stated that top management support, clear goals, and project management are top CSFs in enterprise resource planning.

4.7. Analysing participant perspectives regarding their experience in subway projects

In accordance with participants' experiences of subway projects, a one-way ANOVA was performed on the 39 CSFs. Table 11 summarises the analysis of variance procedure. The p-value indicates the statistical significance of the factors. In this test, the p-value is considered significant when it is below the threshold value of 0.05. As shown in Table 11, the p-value of the analysis of variance exceeds 0.05. Consequently, it is concluded that no significant differences exist among the perspectives of project managers with different years of experience in this industry.

"Insert Table 11 here."

The importance rankings of the CSFs for all project managers with various amounts of experience in subway project can be seen in Table 12 and Figure 2. Chan and Kumaraswamy (1996) stated that "experience" affects the respondents' perception of the importance of CSFs, so it cannot be overlooked. Thus, this variable has to be considered as it may be the cause of differing opinions among the respondents. The results demonstrate that 28 out of the 39 factors received an average of 4 and above, which means they are considered by PMs with any amount of experience as very important. According to Gepp et al. (2014), a high level of expertise of interviewees and experts could positively contribute to the quality of results. It can be attributed to the fact that it takes a significant number of years to gain adequate experience which would enable one to consult or undertake challenging projects. Hence, the experience could enhance the likelihood of a project manager being successful (Garbharran et al. 2012).

In their study, no significant differences were found between years of service among project managers or contractors and their perceptions of critical success factors.

Project managers working in subway construction projects in Iran assume that goal setting is one of the essential CSFs. Some other interesting information may be generated from the data shown in Table 12. For example, participants with more than ten years of experience were of the view that contractor and project manager competency improved the performance of projects and hence their success. Yong and Mustaffa (2013) stated that Contractor's competence and experience is among the top five CSFs for construction projects. Chong et al. (2006) stressed the importance of expertise among project managers to increase the chances of project success. In line with contractor's competency, Phillips et al. (2008) advocated the use of multiple criteria when selecting contractors such as track record, safety practices, quality management and technical ability. Numerous subway projects in Iran are administered under design and build (D&B) contracts. The implications of Ashley et al.'s (1987) findings on D&B projects are that the contractor's project manager should understand and commit to achieving project objectives since the contractor has the sole responsibility for the D&B project. The contractor's capability, competency and experience in managing these projects is critical to project success (Chan et al., 2001). According to Agarwal (1994), more significant experience, understanding, competence and confidence in managing projects will result in a more accurate perception of risk, which increases the chances of project success.

Conversely, project managers with less experience emphasised the role of project cost control, adequate funding throughout the project, and effective allocation of human resources. This hints at the less-experienced project managers' concerns about access to financing and controlling the resources.

"Insert Table 12 here."

498 It can also be observed from Figure 2 that most PMs agreed on the three top-ranked factors. Moreover, it
499 can be seen that "Mutual trust among project stakeholders", received the least consensus among the
500 project managers. It was ranked thirty seconds by the PMs with more than ten years of experience but
501 ranked lower from the view of PMs with less than five years of experience. This shows that project
502 managers with more experience were more appreciative of the importance of mutual trust within the
503 industry. Project managers with more than five years of experience ranked the CSFs close to each other,
504 especially for the factors with MS above the overall average.
505 "Insert Figure 2 here."

506 **5. Conclusion**

507 This study identified and ranked the CSFs for subway construction projects according to their
508 importance, based on the views of contractors' PMs of subway projects in Iran. The success factors
509 found to be critical in subway construction projects in Iran are similar to those of many other developed
510 and developing countries. The literature on critical success factors indicates that research on this subject
511 has been conducted in so many countries including the UK, the USA, Australia, Hong Kong, China,
512 Singapore, Brazil, Canada, Malaysia, Thailand, Vietnam. However, to the extent of our knowledge, no
513 such research has ever been done in Iran, particularly in the context of Tehran subway construction
514 projects. Table 13 shows that type of project aside, the CSFs identified in this paper are of high
515 significance in other countries' construction industries around the world.
516 "Insert Table 13 here."
517 Most of the CSFs are common among diverse types of construction projects. It may be concluded that
518 these CSFs could be used in other construction projects as the triggers of success.
519 Analysis of the survey data was conducted using the MS, and factors with an MS more than 4.05 were
520 divided into three main groups namely project management and planning-related CSFs, project team-

related CSFs and client-related CSFs based on the professionals' opinions from the focus group. The survey results provide a strong foundation for future research exercises aimed at establishing the success of subway and other construction projects. Regarding practical application, project managers can use the results of this study to develop CSFs for their subway construction projects. Project managers can also compare these CSFs with the success factors which they have already experienced in the past. This can prove to be an appropriate knowledge management exercise and may be used as a baseline to establish and implement performance improvement strategies for subway construction projects. Also, project managers can devise measures for improvement to raise the probability of success and reduce the chances of any setbacks in their projects.

The results of this survey suggest the following findings. Goal setting, top management support, PM competency, performance management at each phase, effective allocation of workforce, adequate funding throughout the project, contractor’s competence and experience, multidisciplinary/competent project team, and other factors are shown in Figure 1 are the significant factors critical to the success of a subway construction project.

This study shows that, from the view of contractors, the client can drive the project towards success by providing sufficient support, and adequate funding. Based on the findings and discussions, it is recommended that more emphasis should be placed on improving the project management and planning factors such as competence, goal setting and performance management to ensure the successful implementation of a subway construction project in the future.

Further research should be conducted to determine appropriate strategies to be applied to the Iranian construction environment to achieve success in such developing industry.

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Table 1. Categorization of CSFs

Reference	Categories
Jin et al. (2012)	Project Management-related Client-related Design team-related Contractor-related Business and Work Environment-related
Inayat et al. (2014)	Project characteristics Contractual arrangements Project participants Interactive process
Gudiene et al. (2014)	external institutional project-related project management/team-related project manager-related contractor-related factors client-related
This study	Client-related Project management and planning-related Project team-related External Factors

Table 2. Potential Critical Success Factors

Critical Success Factors

Client-related	
Mutual trust among project stakeholders	Project financing
Effective communication among project stakeholders	Project consultant’s competence
Strong commitment among project stakeholders	Availability of resources
Well-defined scope of work and project constraints	Well-understood and accepted project purpose
Involvement of different project stakeholders in the Early planning of projects	Conflict among project participants
Clear and detailed written contract	Commitment of the project participants
Client’s confidence in construction team	Coordination among project participants
Client’s experience of construction project organization and management	Clear understanding
Client’s responsiveness to the needs of the other stakeholders	Financial security
Constructability	Minimization of conflict between stakeholders
Top management support from client organization	Optimization of legal and administrative services
Nature of client whether she/he is privately or publicly funded	Cooperation in solving problems among project stakeholders
Early and continuous involvement in the project development	Client’s responsiveness to the needs of the other stakeholders
Involvement to monitor project progress	Client track record
Adequacy of funding	Transparency in awarding the job
	Contractual incentives
Project management and planning-related	
Complexity of the project	Establishment of appropriate organizational structure
Urgency in meeting project deadline	Cooperativeness of stakeholders on project
Working relationships with other project stakeholders	Performance management at each phase
Project planning	Contractor’s competence and experience
Goal setting	Stakeholder endorsement of project plans
Effective allocation of human resources	Rich project communications
Legal and contractual risk management	Well-structured and formal project approach
Implementation of effective project monitoring mechanism	Top management support (contractors' organization)
PM competency	Adoption of innovative management approaches
Awarding bids to the right designers/ contractors	Commitment from senior management (Contractor)
Competence (technical and managerial skills)	Consistent with objectives
Leadership and authority	Flexibility to change
Cooperation in solving problems among project Stakeholders	Commitment to quality
Contractor’s competence and experience	Commitment to continuous improvement
Implementing an effective safety program such as SHASSIC	Long-term perspective
Implementing an effective quality assurance program such as QLASSIC	Total cost perspective

Well-defined project scope	Partnership formation at design stage
Effective project budget monitoring	Company wide acceptance (contractor)
Site management and supervision	Questioning attitudes
Competitive procurement	Equal power/empowerment
Transparency in the procurement process	Standardization of decision making process
Tendering method	Good communication and information sharing
Adequacy of plans and specifications	Implementation of effective project monitoring mechanism
PM commitment and involvement	Project value
Budget updates	Project size
Mutual understanding of the scope of work between the Owner and the contractor	Uniqueness
Competent project manager	Innovations
Reasonability of project master and implementation plans	Materials and equipment
Suitability of project management system	Dispute resolution process
Project team-related	
Adaptability to amendment in project plan	Technical expertise
Providing adequate design details and specifications	Team leader's early and continuous involvement in the Project development
Skillful workers	Team leader's adaptability to amendment in project plan
Emphasis on high quality workmanship instead of low and quick construction	Effective project budget monitoring
Project cost control	Team experience
Supervision of subcontractors' works	Troubleshooting
Schedule updates	Decision-making effectiveness
Site inspections	Control system
Team leader's competence	Self-motivation
Multidisciplinary/competent project team	Project organization structure
Project team commitment to project	Personnel issues
Favorable working conditions	Level of automation in project
Dedicated team	Level of skill
Good cultural fit	Training Procedures
External Factors	
Economic	Mutual trust
Social (public acceptance towards the project)	Physical environment
Political	Technological environment
Demand and variation	Logical environment
Nature (weather conditions)	Construction permits
Industry-related issues (availability of resources)	Construction regulations
Construction technology	Product and service certification
Economic risks	Global standards
Balanced adjustment between the public and the private interests	National standards
Owner's competence	Site access limitation
Project nature	Public opinion

effective project management action

Table 3. Final Selected Critical Success Factors

Critical Success Factors	
CSF-1	Urgency in meeting project deadline Project planning
CSF-2	Mutual trust among project stakeholders

CSF-3	Effective communication among project stakeholders
CSF-4	Strong commitment among project stakeholders
CSF-5	Goal Setting
CSF-6	Involvement of different project stakeholders in the early planning of projects
CSF-7	Effective allocation of human resources
CSF-8	Clear and detailed written contract
CSF-9	Legal and contractual risk management
CSF-10	Implementation of effective project monitoring mechanism
CSF-11	Project financing (cash flow)
CSF-12	Client's experience of construction project organization and management
CSF-13	Client's responsiveness to the needs of the other stakeholders
CSF-14	Top management support from client organization
CSF-15	Adaptability to amendment in project plan
CSF-16	Leadership and authority
CSF-17	Providing adequate design details and specifications
CSF-18	Cooperation in solving problems among project stakeholders
CSF-19	Contractor's competence and experience
CSF-20	Supervision of subcontractors' works
CSF-21	Skillful workers
CSF-22	Effective project budget monitoring
CSF-23	Site management and supervision
CSF-24	Transparency in the procurement process
CSF-25	PM competency
CSF-26	PM commitment and involvement
CSF-27	Schedule updates
CSF-28	Site inspections
CSF-29	Adequate funding throughout the project
CSF-30	Multidisciplinary/competent project team
CSF-31	Conflict among project participants,
CSF-32	Favorable working conditions,
CSF-33	Adoption of innovative management approaches.
CSF-34	Flexibility to change
CSF-35	Commitment to quality
CSF-36	Good cultural fit
CSF-37	Financial security
CSF-38	Performance management at each phase
CSF-39	Project consultant's competence

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872 Table 4. Characteristics of Respondents

Items	Construction

Gender		
Male	57	90.5
Female	6	9.5
Age		
Less than 25 years	4	6.3
25 to below 35 years	14	22.2
36 to below 45 years	38	60.3
More than 46 years	7	11.1
Experience in Subway Construction Project Management		
Less than 2 years	7	11.1
2 to below 5 years	15	23.8
6 to below 10 years	26	41.3
More than 10 years	15	23.8
Experience in Civil Engineering		
Less than 2 years	2	3.2
2 to below 5 years	14	22.2
6 to below 10 years	11	17.5
More than 10 years	36	57.1
Educational Background		
Bachelor of Science	36	57.1
Master of Science	20	31.7
MBA/ DBA	3	4.8
PhD	4	6.3

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881 Table 5. Ranking of perceived importance of the success factors

Success Factor	Mean	SD	Rank

Goal Setting	4.714	0.669	1
Top management support from client organization	4.492	1.400	2
PM competency	4.460	0.872	3
Performance management at each phase	4.460	1.090	4
Effective allocation of human resources	4.444	0.547	5
Adequate funding throughout the project	4.444	1.013	6
Contractor's competence and experience	4.413	0.637	7
Multidisciplinary/competent project team	4.381	1.330	8
Project cost control (e.g. cash flow)	4.365	0.973	9
Project consultant's competence	4.317	1.161	10
Good cultural fit	4.302	1.199	11
Effective project budget monitoring	4.254	1.126	12
Favorable working conditions,	4.238	0.882	13
Site management and supervision	4.190	0.794	14
Financial security	4.190	0.678	15
Supervision of subcontractors' works	4.175	0.990	16
Adoption of innovative management approaches	4.159	1.258	17
Providing adequate design details and specifications	4.143	0.628	18
Client's responsiveness to the needs of the other stakeholders	4.127	0.705	19
Clear and detailed written contract	4.095	0.702	20
Skillful workers	4.063	0.664	21
Strong commitment among project stakeholders	4.048	0.590	22
Cooperation in solving problems among project stakeholders	4.048	0.753	23
Client's experience of construction project organization and management	4.032	1.198	24
Schedule updates	4.032	0.793	25
Adaptability to amendment in project plan	4.016	1.061	26
Effective communication among project stakeholders	3.968	0.796	27
Site inspections	3.905	0.830	28
Urgency in meeting project deadline	3.889	0.972	29
Flexibility to change	3.825	0.744	30
Leadership and authority	3.810	1.115	31
Commitment to quality	3.746	1.123	32
Transparency in the procurement process	3.730	0.820	33
Legal and contractual risk management	3.683	0.968	34
Implementation of effective project monitoring mechanism	3.619	1.234	35
PM commitment and involvement	3.619	0.658	36
Mutual trust among project stakeholders	3.571	0.923	37
Involvement of different project stakeholders in the early planning of projects	3.365	0.957	38
Conflict among project participants,	2.794	0.638	39

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885 Table 6. Ranking of project management and planning-related critical success factors

Critical Success Factor	Mean	SD	Ranking
Goal Setting	4.714	0.669	1
PM Competency	4.460	0.872	2
Performance management at each phase	4.460	1.090	3

Effective allocation of human resources	4.444	0.547	4
Contractor's competence and experience	4.413	0.637	5
Effective project budget monitoring	4.254	1.126	6
Site management and supervision	4.190	0.794	7
Adoption of innovative management approaches	4.159	1.258	8
Clear and detailed written contract	4.095	0.702	9

Table 7. Ranking of project team-related critical success factors

Critical Success Factor	Mean	SD	Ranking
Multidisciplinary/ Competent project team	4.381	1.330	1
Project cost control (e.g. cash flow)	4.365	1.199	2
good cultural fit	4.302	0.990	3
Favorable working conditions	4.238	0.973	4
Supervision of subcontractors' works	4.175	0.664	5
Skillful workers	4.063	1.330	6

Table 8. Ranking of client-related critical success factors

Critical Success Factor	Mean	SD	Ranking
Top management support from client organization	4.492	1.013	1
Adequate funding throughout the project	4.444	1.161	2
Project consultant's competence	4.317	0.678	3
Financial security	4.190	0.628	4
Providing adequate design details and specifications	4.143	0.705	5
Client's responsiveness to the needs of the other stakeholders	4.127	0.590	6

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939 Table 9- Correlation matrix of CSFs for subway construction projects (a)

	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6	CSF7	CSF8	CSF9	CSF10	CSF11	CSF12	CSF13	CSF14	CSF15	CSF16	CSF17	CSF18	CSF19	CSF20
CSF1	1.000																			
CSF2	0.068	1.000																		
CSF3	0.184	0.405	1.000																	
CSF4	0.029	0.440	0.636	1.000																
CSF5	0.043	0.379	0.413	0.635	1.000															
CSF6	0.128	0.450	0.229	0.001	0.012	1.000														
CSF7	0.331	0.481	0.340	0.633	0.410	0.093	1.000													
CSF8	0.113	0.508	0.317	0.490	0.430	0.297	0.531	1.000												
CSF9	0.043	0.378	0.418	0.792	0.635	0.076	0.381	0.305	1.000											
CSF10	0.054	0.241	0.208	0.378	0.304	0.159	0.637	0.270	0.385	1.000										
CSF11	0.048	0.226	0.102	0.375	0.401	0.112	0.536	0.396	0.412	0.716	1.000									
CSF12	0.068	0.703	0.179	0.387	0.478	0.497	0.533	0.613	0.357	0.458	0.450	1.000								
CSF13	0.185	0.378	0.150	0.423	0.338	0.336	0.267	0.504	0.472	0.264	0.572	0.571	1.000							
CSF14	0.076	0.589	0.435	0.615	0.762	0.105	0.635	0.602	0.592	0.617	0.628	0.728	0.523	1.000						
CSF15	0.136	0.174	0.055	0.428	0.354	0.055	0.131	0.139	0.561	0.133	0.090	0.020	0.235	0.162	1.000					
CSF16	0.064	0.002	0.044	0.156	0.134	0.137	0.218	0.062	0.250	0.118	0.115	0.020	0.228	0.099	0.312	1.000				
CSF17	0.528	0.413	0.105	0.227	0.244	0.465	0.099	0.258	0.167	0.222	0.228	0.646	0.484	0.390	0.244	0.137	1.000			
CSF18	0.050	0.005	0.206	0.321	0.271	0.302	0.145	0.318	0.103	0.068	0.082	0.334	0.304	0.335	0.073	0.142	0.273	1.000		
CSF19	0.232	0.517	0.305	0.222	0.182	0.211	0.405	0.551	0.029	0.309	0.367	0.544	0.299	0.403	0.279	0.251	0.542	0.135	1.000	
CSF20	0.094	0.415	0.009	0.115	0.212	0.201	0.146	0.169	0.011	0.315	0.094	0.374	0.010	0.358	0.039	0.021	0.062	0.091	0.239	1.000
CSF21	0.409	0.142	0.298	0.136	0.125	0.365	0.255	0.151	0.215	0.072	0.011	0.103	0.230	0.119	0.108	0.163	0.445	0.374	0.046	0.058
CSF22	0.232	0.555	0.324	0.573	0.520	0.182	0.460	0.252	0.527	0.419	0.362	0.728	0.396	0.614	0.188	0.083	0.507	0.224	0.244	0.314
CSF23	0.357	0.318	0.420	0.453	0.440	0.008	0.353	0.220	0.343	0.465	0.380	0.517	0.346	0.507	0.223	0.122	0.642	0.216	0.510	0.003
CSF24	0.077	0.707	0.037	0.107	0.294	0.612	0.282	0.574	0.117	0.177	0.201	0.653	0.363	0.557	0.142	0.104	0.278	0.312	0.376	0.622
CSF25	0.053	0.678	0.549	0.525	0.486	0.008	0.632	0.605	0.313	0.484	0.507	0.534	0.370	0.699	0.014	0.151	0.300	0.179	0.711	0.283
CSF26	0.075	0.713	0.433	0.483	0.578	0.196	0.533	0.656	0.452	0.566	0.484	0.781	0.510	0.844	0.030	0.127	0.469	0.218	0.550	0.537
CSF27	0.036	0.269	0.067	0.346	0.422	0.349	0.254	0.252	0.587	0.528	0.553	0.548	0.582	0.553	0.146	0.189	0.407	0.219	0.146	0.160
CSF28	0.190	0.170	0.223	0.065	0.185	0.393	0.020	0.353	0.139	0.226	0.322	0.343	0.385	0.360	0.172	0.210	0.028	0.283	0.040	0.382
CSF29	0.046	0.467	0.166	0.489	0.686	0.133	0.553	0.556	0.585	0.656	0.759	0.712	0.582	0.847	0.182	0.071	0.402	0.173	0.404	0.305
CSF30	0.340	0.072	0.068	0.369	0.462	0.037	0.112	0.284	0.321	0.242	0.396	0.364	0.410	0.381	0.043	0.206	0.671	0.267	0.306	0.158
CSF31	0.137	0.057	0.124	0.162	0.033	0.123	0.072	0.206	0.177	0.098	0.145	0.068	0.043	0.025	0.227	0.079	0.036	0.009	0.028	0.116
CSF32	0.049	0.681	0.316	0.380	0.550	0.146	0.584	0.686	0.331	0.606	0.619	0.797	0.499	0.848	0.026	0.012	0.414	0.186	0.578	0.430
CSF33	0.379	0.377	0.162	0.453	0.313	0.223	0.078	0.014	0.620	0.180	0.215	0.338	0.433	0.343	0.195	0.272	0.578	0.015	0.161	0.035
CSF34	0.005	0.020	0.025	0.098	0.064	0.081	0.126	0.418	0.126	0.124	0.109	0.053	0.197	0.136	0.270	0.035	0.188	0.091	0.383	0.021
CSF35	0.023	0.782	0.199	0.257	0.316	0.599	0.386	0.460	0.290	0.365	0.170	0.737	0.321	0.581	0.014	0.064	0.473	0.179	0.449	0.637
CSF36	0.148	0.485	0.404	0.157	0.063	0.332	0.210	0.366	0.026	0.150	0.001	0.480	0.180	0.232	0.295	0.277	0.408	0.311	0.622	0.126
CSF37	0.137	0.309	0.441	0.669	0.736	0.108	0.342	0.515	0.686	0.334	0.468	0.528	0.516	0.716	0.249	0.161	0.386	0.368	0.245	0.027
CSF38	0.069	0.467	0.455	0.710	0.706	0.157	0.524	0.502	0.737	0.430	0.573	0.546	0.495	0.746	0.356	0.026	0.222	0.360	0.236	0.049
CSF39	0.231	0.312	0.104	0.090	0.169	0.425	0.074	0.526	0.042	0.142	0.014	0.494	0.295	0.287	0.305	0.096	0.458	0.160	0.450	0.443

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Table 10-Correlation matrix of CSFs for subway construction projects (b)

CSF21	CSF22	CSF23	CSF24	CSF25	CSF26	CSF27	CSF28	CSF29	CSF30	CSF31	CSF32	CSF33	CSF34	CSF35	CSF36	CSF37	CSF38	CSF39
1.000																		
0.121	1.000																	
0.071	0.570	1.000																
0.121	0.344	0.039	1.000															
0.176	0.395	0.518	0.481	1.000														
0.101	0.611	0.508	0.681	0.737	1.000													
0.206	0.422	0.387	0.309	0.228	0.484	1.000												
0.155	0.082	0.098	0.581	0.115	0.373	0.653	1.000											
0.005	0.523	0.491	0.471	0.578	0.765	0.699	0.426	1.000										
0.369	0.394	0.551	0.116	0.133	0.264	0.382	0.018	0.490	1.000									
0.347	0.162	0.104	0.137	0.054	0.013	0.082	0.013	0.062	0.018	1.000								
0.127	0.508	0.472	0.650	0.768	0.903	0.524	0.450	0.819	0.233	0.153	1.000							
0.127	0.572	0.414	0.060	0.156	0.325	0.551	0.069	0.310	0.421	0.277	0.183	1.000						
0.042	0.244	0.129	0.164	0.288	0.204	0.199	0.396	0.170	0.216	0.371	0.312	0.015	1.000					
0.020	0.525	0.325	0.802	0.476	0.739	0.461	0.426	0.491	0.002	0.142	0.639	0.353	0.077	1.000				
0.008	0.212	0.461	0.285	0.525	0.347	0.164	0.082	0.113	0.025	0.366	0.397	0.088	0.341	0.446	1.000			
0.020	0.465	0.496	0.190	0.422	0.593	0.532	0.189	0.719	0.588	0.100	0.553	0.358	0.176	0.237	0.167	1.000		
0.146	0.440	0.429	0.288	0.537	0.533	0.564	0.235	0.719	0.311	0.074	0.593	0.291	0.050	0.301	0.284	0.853	1.000	
0.140	0.123	0.171	0.486	0.244	0.531	0.293	0.447	0.284	0.247	0.337	0.493	0.086	0.450	0.526	0.453	0.275	0.073	1.000

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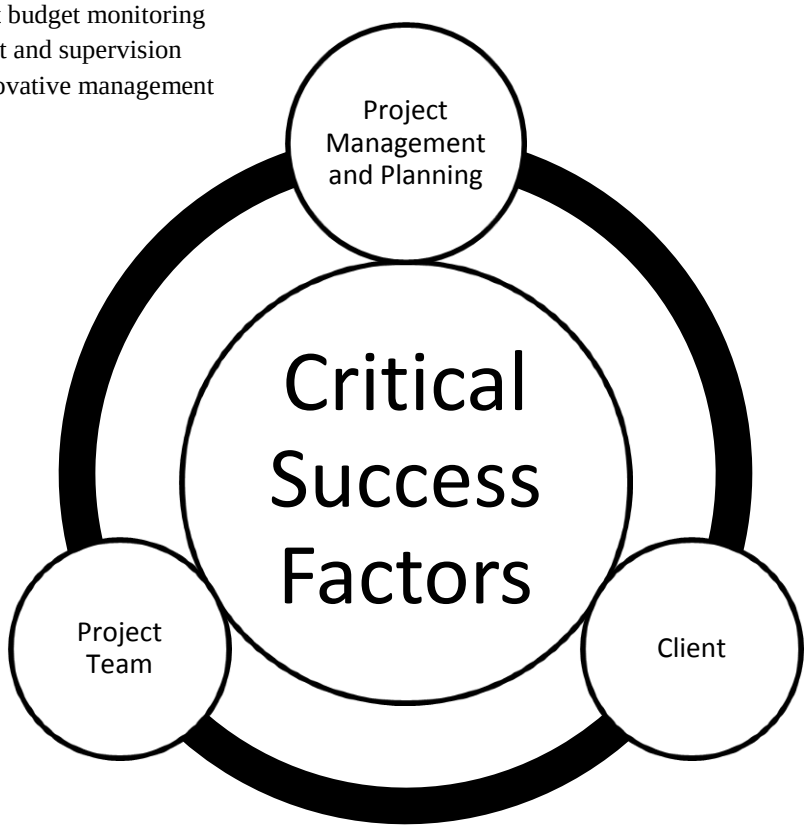
1. Goal Setting
2. PM Competency
3.Performance management at each phase
4.Effective allocation of manpower
5.Contractor's competence and experience
6.Effective project budget monitoring
7.Site management and supervision
8.Adoption of innovative management



1. Multidisciplinary/ Competent project team
2. Good cultural fit
3. Favorable working conditions
4.Supervision of subcontractors' works
5. Skillful workers
6.Project cost control (e.g. cash flow)

7. Top management support from client organization
8. Adequate funding throughout the project
9. Project consultant's competence
10. Financial security
11. Providing adequate design details and specifications
12. Client's responsiveness to the needs of the other stakeholders

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955 Figure 1. Consolidated Framework of CSFs for subway construction projects

Table 11. Analysis of variance for CSFs from the perspective of project managers with different amount of experience

Source	Sum of Squares	D.f.	Mean Square	F	Sig.
Between Groups	1.397	3	0.466	2.706	0.061
Within Groups	26.167	152	0.172		
Total	27.564	155			

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983 Table 12. Comparison of CSFs for subway projects among PMs with different amount
984 of experience

ID	CSFs by overall ranking *n = 63*	PMs with more than 10 years of experience *n = 15*		PMs with 6 to 10 years of experience *n = 26*		PMs with 2 to 5 years of experience *n = 15*		PMs with less than 5 years of experience *n = 7*	
		Rank	MS	Rank	MS	Rank	MS	Rank	MS
1	Goal Setting	2	4.667	1	4.692	1	4.733	2	4.857
2	Top management support from client organization	7	4.533	4	4.385	4	4.533	6	4.714
3	PM competency	3	4.667	2	4.423	7	4.333	12	4.429
4	Performance management at each phase	16	4.467	5	4.385	5	4.533	9	4.571
5	Effective allocation of human resources	5	4.600	3	4.385	9	4.267	4	4.714
6	Adequate funding throughout the project	4	4.667	7	4.269	8	4.333	3	4.857
7	Contractor's competence and experience	1	4.733	6	4.269	6	4.333	11	4.429
8	Multidisciplinary/competent project team	8	4.533	12	4.154	2	4.600	13	4.429
9	Project cost control (e.g. cash flow)	11	4.467	16	4.038	3	4.533	1	5.000
10	Project consultant's competence	10	4.533	9	4.231	18	4.133	10	4.571
11	Good cultural fit	9	4.533	8	4.269	15	4.200	25	4.143
12	Effective project budget monitoring	13	4.467	10	4.192	17	4.133	17	4.286
13	Favorable working conditions,	15	4.467	14	4.115	25	4.000	7	4.714
14	Site management and supervision	14	4.467	18	4.038	10	4.267	29	4.000
15	Financial security	19	4.333	19	4.038	12	4.267	18	4.286
16	Supervision of subcontractors' works	12	4.467	15	4.077	24	4.000	16	4.286
17	Adoption of innovative management approaches	18	4.400	22	4.000	11	4.267	31	4.000
18	Providing adequate design details and specifications	6	4.600	28	3.923	21	4.067	21	4.143
19	Client's responsiveness to the needs of the other stakeholders	24	4.133	17	4.038	19	4.067	8	4.571
20	Clear and detailed written contract	23	4.133	13	4.115	29	3.733	5	4.714
21	Skillful workers	25	4.133	26	3.962	31	4.133	22	4.143
22	Strong commitment among project stakeholders	22	4.133	20	4.000	23	4.000	19	4.143
23	Cooperation in solving problems among project stakeholders	29	4.000	21	4.000	13	4.200	28	4.000
24	Client's experience of	17	4.400	24	3.962	31	3.667	15	4.286

	construction project organization and management								
25	Schedule updates	21	4.200	30	3.808	14	4.200	23	4.143
26	Adaptability to amendment in project plan	36	3.733	11	4.154	20	4.067	27	4.000
27	Effective communication among project stakeholders	28	4.000	23	3.962	26	3.933	26	4.000
28	Site inspections	31	4.000	34	3.692	22	4.067	24	4.143
29	Urgency in meeting project deadline	27	4.000	31	3.769	28	3.800	29	4.286
30	Flexibility to change	34	3.800	27	3.962	33	3.600	33	3.857
31	Leadership and authority	37	3.667	25	3.962	27	3.933	38	3.286
32	Commitment to quality	20	4.267	35	3.654	37	3.333	34	3.857
33	Transparency in the procurement process	33	3.867	29	3.808	36	3.333	33	4.000
34	Legal and contractual risk management	35	3.733	33	3.692	30	3.667	36	3.571
35	Implementation of effective project monitoring mechanism	26	4.067	38	3.269	34	3.533	20	4.143
36	PM commitment and involvement	30	4.000	36	3.462	35	3.400	32	3.857
37	Mutual trust among project stakeholders	32	3.933	32	3.692	38	2.933	35	3.714
38	Involvement of different project stakeholders in the early planning of projects	38	3.267	37	3.269	32	3.600	37	3.429
39	Conflict among project participants,	39	2.533	39	2.923	39	2.867	39	2.714

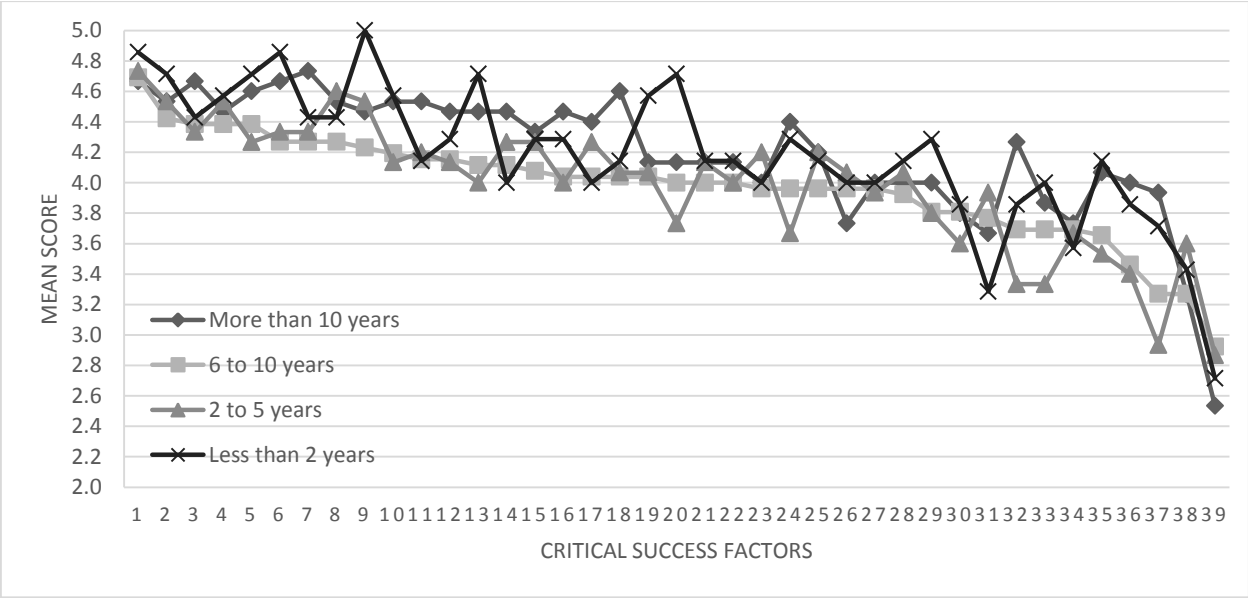

Figure 2. Cross-comparison of CSFs' importance among PMs with different experience.

1012 Table 13. Conformity of CSFs

Rank	Critical Success factor	Country	Reference
1	Goal setting	Vietnam, UK, Thailand, China, Canada, Brazil	*Nguyen et al. (2004), Fortune and White (2006), Toor and Ogulana (2009), Elwakil et al. (2009), Zhao et al. (2013), Osorio et al. (2014)*
2	Top management Support	Canada, Thailand, India, Malaysia, Global, Brazil	*Belout and Gauvreau (2004), Toor and Ogulana (2009), Tabish and Jha (2011), Jin et al. (2012), Gepp et al. (2014), Osorio et al. (2014)*
3	PM Competency	Lithuania, Ukraine, Malaysia, Global	*Gudiene et al. (2013), Didenko and Konovets (2009), Jin et al. (2012), Gepp et al. (2014)*
4	Performance management at each phase	Europe, UK	*Cooke-Davies (2002), Banfield (2005)*
5	Effective allocation of human resources	UK, Thailand, Malaysia	*Fortune and White (2006), Toor and Ogulana (2009), Yong and Mustaffa (2013)*
6	Adequate funding throughout the project	UK, Singapore, Global, Malaysia	*Fortune and White (2006), Hwang et al. (2013), Inayat et al. (2012), Yong and Mustaffa, (2012)*
7	Contractor's competence and experience	Hong Kong, Global	*Chan et al. (2001), Inayat et al. (2012)*
8	Competent Project Team	UK, USA, Australia, Hong Kong, Brazil	*Yu and Shen (2014), Osorio et al. (2014)*
9	Project cost control (e.g. cash flow)	Global, Brazil, India	*Inayat et al. (2012), Osorio et al. (2014), Gadekar and Pimplikar (2014)*
10	Project consultant's competence	Global, Malaysia	*Inayat et al. (2012), Yong and Mustaffa (2013)*

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